Chapter 3 North-of-the-Delta Offstream Storage Investigation

The Department of Water Resources (DWR), the U.S. Bureau of Reclamation (Reclamation), and local partners are investigating potential offsteam storage north-of-the-Delta in the Sacramento Valley (See Box 3-1 for a list of acronyms and abbreviations used in this section). The investigation purpose is to evaluate the feasibility of northern Sacramento Valley storage to improve water supply and water supply reliability, improve Sacramento-San Joaquin Delta (Delta) water quality, and increase the survival of anadromous fish and other aquatic species. Much of the information presented here is summarized from the North-of-the-Delta Offstream Storage (NODOS) Investigation Plan Formulation Report (PFR) (Reclamation, 2008a). However, this section also summarizes new analyses for the NODOS Investigation reflecting recent water management changes, including the 2008 US Fish and Wildlife Service (USFWS) and 2009 National Marine Fisheries Service (NMFS) Biological Opinions (BO). Sensitivity analyses are also presented on proposed new Delta conservation and conveyance actions. Climate change impacts to the potential benefits and operations of the example project formulation are also described.

Study Areas

NODOS would affect environmental and water resources in various ways in different geographic areas. To effectively evaluate these differing effects, three study areas were identified for the NODOS Investigation: the Primary Study Area, the Secondary Study Area, and the Extended Study Area, as described below.

The Primary Study Area (See Figure 3-1) for the NODOS Investigation encompasses the upper Sacramento River and the northern Sacramento Valley and includes watersheds flowing into the upper Sacramento River from Colusa, Tehama, and Glenn counties, as well as smaller portions of Shasta, Sutter, and Butte counties. It includes the Sites Reservoir inundation area and new project facilities (e.g., dams, fish screens, pipelines, pumping/power plants, recreation areas, road relocation areas, and borrow areas).

The Secondary Study Area includes the State Water Project (SWP) and Central Valley Project (CVP) facilities that could experience reservoir water surface elevation fluctuations and stream flow changes downstream from their facilities. Those potential changes could occur as a result of the coordinated and integrated operation of a NODOS project facilities with those state and federal projects located on the American River, Trinity River, Sacramento River, Clear Creek, Spring Creek, Feather River, and the Delta.

The Extended Study Area includes the entire service areas of the SWP and CVP. This is because one of the NODOS primary objectives of improved water supply reliability has the potential for long-term direct and indirect effects within those two service areas.

The effects of a NODOS project in the three study areas will be analyzed in the draft and final Environmental Impact Report (EIR) and Environmental Impact Statement (EIS).

Box 3-1. Chapter 3 Acronym and Abbreviation List

AF	acre-feet
BO	Biological Opinion
CALFED	CALFED Bay-Delta Program
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento-San Joaquin Delta
DWR	Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ERA	Ecosystem Restoration Account
ERP	CALFED Ecosystem Restoration Program
^{o}F	degrees Fahrenheit
GCID	Glenn-Colusa Irrigation District
IAIR	Initial Alternatives Information Report
M&I	municipal and industrial
MAF	million acre-feet
mg/L	milligrams per liter
msl	mean sea level
NA	not applicable
NEPA	National Environmental Policy Act
NM	not modeled
NMFS	National Marine Fisheries Service
NODOS	North-of-the-Delta Offstream Storage
PFR	Plan Formulation Report
Reclamation	United States Bureau of Reclamation
ROD	Record of Decision
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TC	Tehama-Colusa
TCCA	Tehama-Colusa Canal Authority
TDS	total dissolved solids
TRR	Terminal Regulating Reservoir
USFWS	United States Fish and Wildlife Service
WRC	Water Resources Council

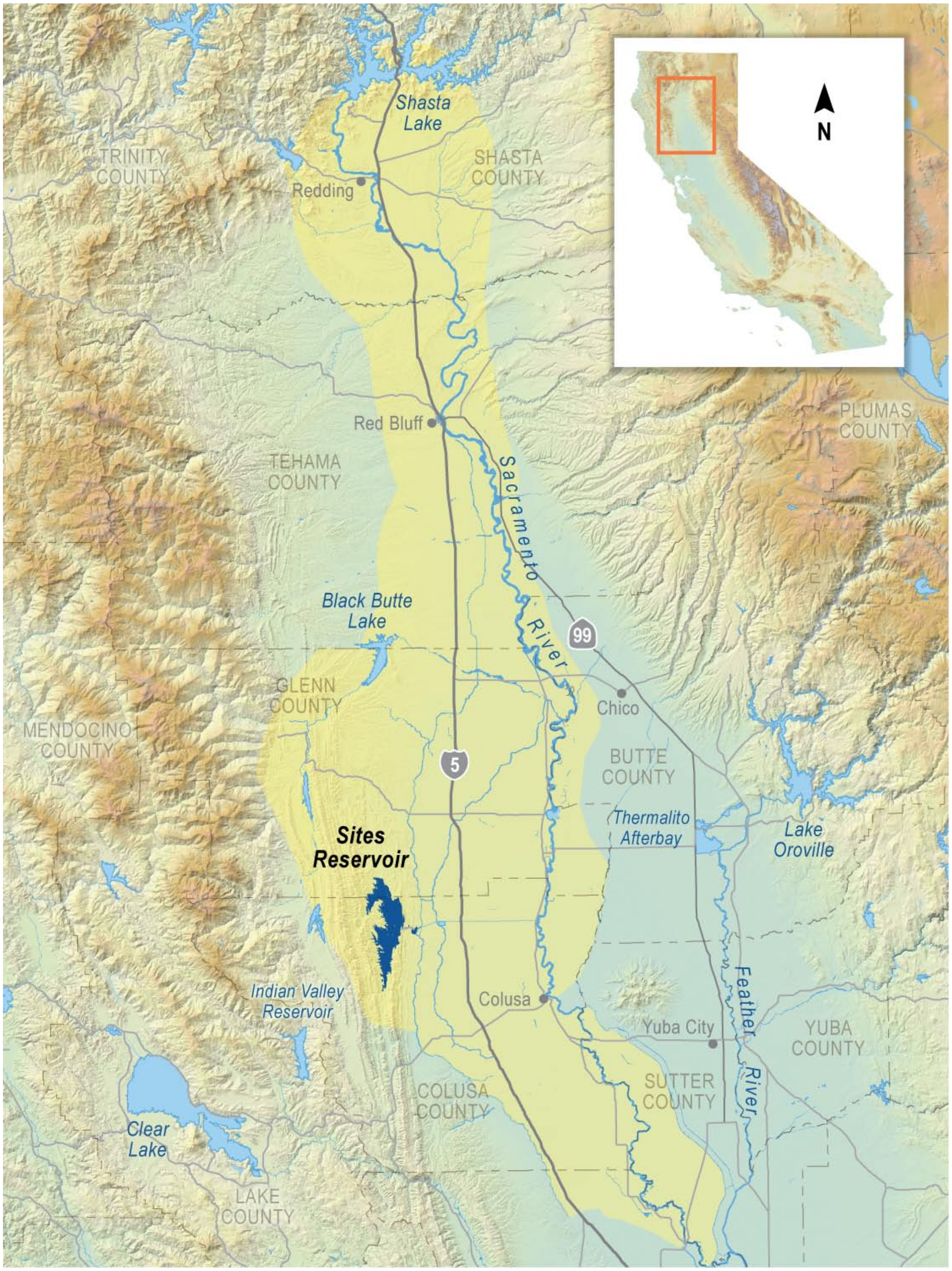

Figure 3-1. NODOS Investigation Primary Study Area

Project Objectives

The NODOS PFR describes problems, needs, and opportunities in the study areas that served as the basis for the NODOS Investigation planning objectives. Some of the problems and needs are also described more generally in Chapter 2. This section briefly summarizes the problems, needs, and opportunities for the NODOS Investigation and presents NODOS planning objectives.

Water Supply and Water Supply Reliability

The California Water Plan and the CALFED Bay-Delta Program (CALFED) Record of Decision (ROD) both recognized the need for increased water supply and water supply reliability, especially during dry years. SWP and CVP contractors are subject to dry-year deficiencies and are especially vulnerable to droughts. During extended droughts, decreased agricultural deliveries often force water users to either use groundwater to replace surface water supply or remove agricultural acreage from production (DWR, 2005). Decreased municipal and industrial (M&I) deliveries often result in rationing or acquisition of other temporary sources.

In the 1990s, protective actions, including the Central Valley Project Improvement Act (CVPIA) and the *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (SWRCB, 1995), reduced the ability of the SWP and CVP to contribute to statewide water supply reliability. CALFED estimated that these two protective actions reduced water contract deliveries by more than 1 million acre-feet (MAF) annually during dry periods. More recently, the 2008 USFWS and 2009 NMFS BOs further reduced the annual delivery capability of the SWP and CVP.

Similar to M&I and agricultural water supply, Level 4 water supplies for California's wildlife refuges are not reliable. CVPIA called for the CVP to provide two types of refuge water supply: Level 2, which was to be provided by CVP yield and incremental Level 4, which was an additional amount above Level 2 and was to be acquired. According to estimates by the USFWS, only about 50% of the incremental Level 4 supplies are acquired each year from willing sellers, partly due to too few willing sellers and/or insufficient funding.

The NODOS Investigation is evaluating the use of offstream storage to provide additional water supply and improve water supply reliability for M&I and agricultural users and wildlife refuges. Water stored in the winter during higher flow conditions in the Sacramento River would be available for use throughout the year and allow additional water to be carried over in storage from year to year. Additional water in storage is especially helpful for mitigating the effects of drought, or multiple dry years.

Survival of Anadromous Fish and Other Aquatic Species

Loss of riparian habitat, the operations of dams and pumping facilities, polluted runoff, and changes in geomorphology have negatively affected populations of anadromous fish and other aquatic species in the Sacramento River and Delta. Fish species of primary concern that are affected by water operations in the Sacramento River and Delta include winter-run Chinook salmon, delta smelt, river lamprey, Central Valley steelhead, spring-run Central Valley Chinook, fall and late fall-run Chinook, green sturgeon, and Sacramento splittail. Non-listed fish species that also may be affected by water operations include striped bass, Pacific lamprey, white sturgeon, and American shad.

The NODOS Investigation is analyzing the ability to change systemwide CVP/SWP operations to improve the reliability of the projects in meeting reasonable and prudent alternatives of the 2008/2009 BOs, such as anadromous fish migration flows and cooler water for fish spawning habitat. Additionally, the NODOS Investigation can provide considerable benefits to fish and other aquatic species by accomplishing some of the objectives identified in the CALFED Ecosystem Restoration Program (ERP). The ERP adaptive management implementation approach, which supports the flexible use of environmental water, has been accommodated in NODOS planning by dedicating a NODOS storage allocation to ERP and BO objectives. A potential NODOS project may benefit anadromous fish and other aquatic species by providing additional flows in the Sacramento River and Delta for environmental purposes and increasing the cold water pool at Shasta Lake.

Delta Water Quality

The Delta is the diversion point for drinking water for millions of Californians, is critical to California's agricultural sector, and supports a diverse and unique ecosystem. As such, the quality of water in the Delta is very important. Typically, April through July are the most favorable months for the Delta to be used as a source of drinking water. Outflow from natural runoff is usually high enough during this period to push seawater out of the Delta. This period is also outside of the peak loading time for agricultural drainage. Management actions taken to address fishery concerns have resulted in a shift in exports from the higher water quality spring months to the typically lower water quality fall months, with a corresponding degradation in delivered water quality.

Improved water quality in the Delta is needed for drinking water, agriculture, and ecosystem restoration. The composition requirements of each end use vary, but the key indicators of Delta water quality are salinity, toxins, and agricultural drainage components. Habitat quality in the Delta depends on many of these same factors and, more specifically, the survivability of fish and other aquatic species depends on the water quality of the estuary. The NODOS Investigation is evaluating methods to improve water quality by providing supplemental flows of high quality water when water quality is impaired.

Opportunities

Generally, accomplishing objectives associated with opportunities have a lower priority in the project formulation process than achieving the objectives associated with problems and needs. The NODOS Investigation recognizes opportunities to accomplish hydropower/flexible generation, recreation, flood damage reduction, and emergency water objectives.

Planning Objectives

Based on the problems, needs, and opportunities identified for the NODOS Investigation, three primary and three secondary planning objectives have been developed. Identified problems and needs have become primary objectives, while opportunities have become secondary objectives.

Primary Planning Objectives

- Increase water supplies to meet existing contract requirements, including improved water supply reliability, and provide greater flexibility in water management for agricultural, environmental, and M&I users

- Increase the survival of anadromous fish populations in the Sacramento River, as well as the survivability of other aquatic species
- Improve drinking and environmental water quality in the Delta

While meeting the primary planning objectives, the NODOS Investigation will recognize opportunities to accomplish the following:

Secondary Planning Objectives

- Provide flexible generation benefits to facilitate reliable operation of statewide power grid with an ever increasing percent of wind and solar generation
- Develop additional recreational opportunities in the Primary Study Area
- Create incremental flood damage reduction opportunities in support of major northern California flood control reservoirs

Project Formulation and Initial Alternatives

The formulation of initial alternative plans for the NODOS Investigation began with concepts identified in the CALFED ROD (CALFED, 2000b) and continued with the NODOS Initial Alternatives Information Report (IAIR) (Reclamation and DWR, 2006). The IAIR was the first stage in the federal planning process, which identified many features and activities that met the planning objectives. The IAIR summarized the preliminary screening of alternative reservoir locations, conveyance systems, and other features as potential candidates for providing storage within the northern Sacramento Valley. Recognizing the limited scope of the IAIR and the iterative nature of the planning process, the NODOS PFR re-examined the problems and needs, planning objectives and constraints, and provided a more complete evaluation of potential project alternatives. The PFR identified a No-Action Alternative Plan and eight Initial Action Alternative Plans:

- Three initial action alternatives with a water supply focus (WS1A, WS1B, and WS1C)
- Two initial action alternatives with an environmental enhancement focus to improve the survival of anadromous fish and other aquatic species (AF1A and AF1B)
- Two initial action alternatives with a water quality focus (WQ1A and WQ1B)
- One initial action alternative with fish enhancements and operations designed to maximize water supply, fishery, and water quality benefits (WSFQ)

Each of the initial action alternatives met the three primary objectives, but to varying degrees. The "focus" indicated above identifies the relative priority of the use of the facilities associated with NODOS. Several features were common to all of the initial action alternative plans, including a 1.8 MAF Sites Reservoir, two major dams and nine saddle dams, and appurtenant features (See Figure 3-2).

Each of the initial action alternative plans includes dedicated storage allocations to ERP objectives. The NODOS planning team identified ERP objectives that could be supported by implementing a potential NODOS project. Ultimately, the selected ERP objectives were incorporated into the operations strategy for the initial action alternatives.

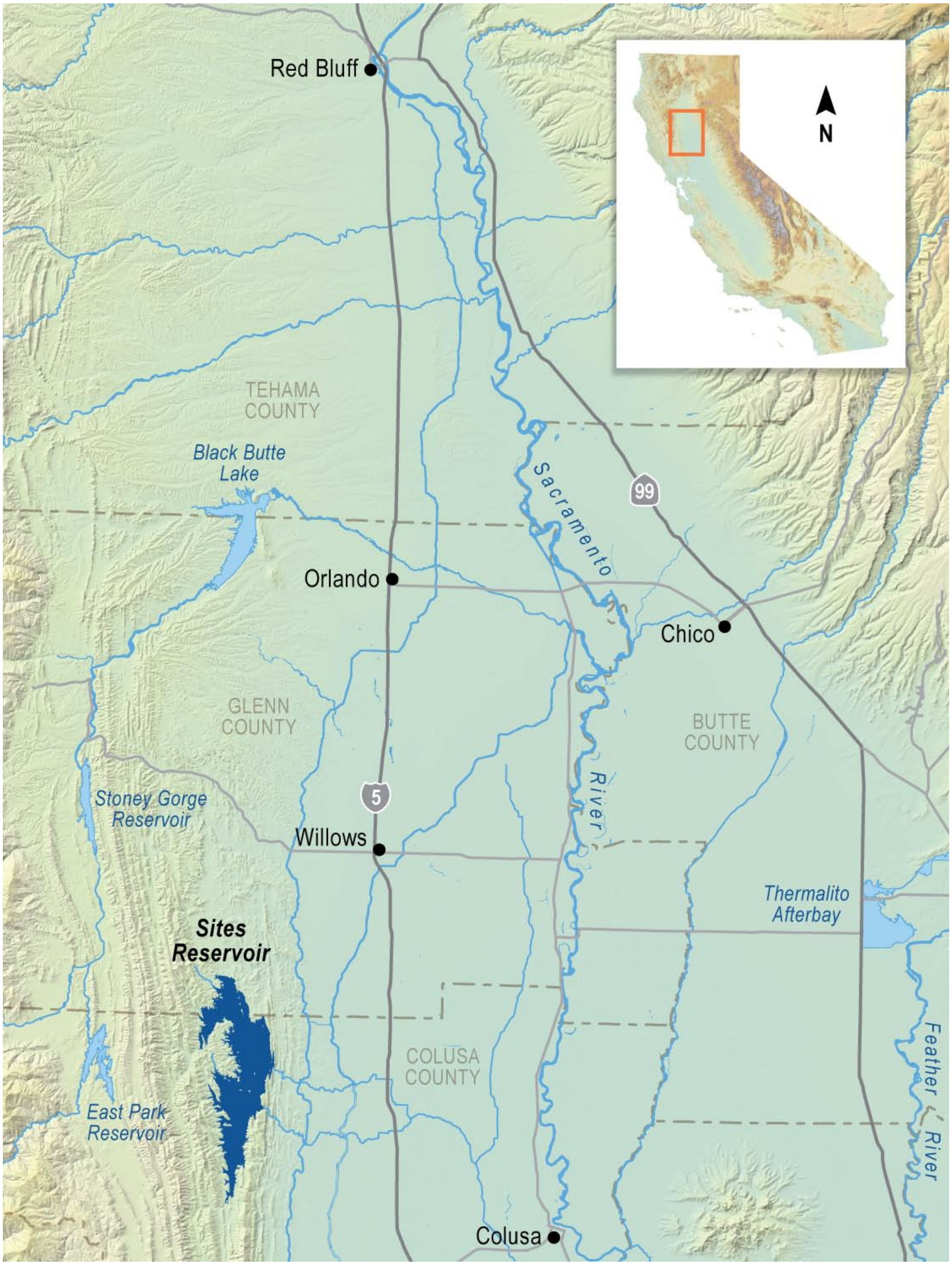

Figure 3-2. Sites Reservoir Project Location

As summarized in the PFR, each of the initial action alternative plans was formulated to address the NODOS Investigation's planning objectives and constraints. The PFR presented a preliminary evaluation of initial alternative plans based on the benefits, costs, and criteria of completeness, effectiveness, efficiency, and acceptability, as identified in the federal planning guide *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (WRC, 1983). Based on the analysis of accomplishments, benefits, and costs and comparison of alternative plans using the four federal planning criteria, the PFR suggested that three of the eight initial action alternative plans be recommended for additional investigation in the feasibility study:

- Initial Action Alternative Plan WSFQ
- Initial Action Alternative Plan WS1A
- Initial Action Alternative Plan WQ1B

As with all the surface storage studies, NODOS alternative analysis and evaluation is an iterative process and as conditions change and new information becomes available previously screened or new measures and alternative plans may be added. Future evaluations may include the optimization of any of the alternatives carried forward in the feasibility study. When all relevant analyses have been completed, a Recommended Plan and the rationale for selection will be identified in the draft Feasibility Report and EIS/EIR.

Example Sites Reservoir Project Formulation Features and Costs

This section describes an example Sites Reservoir project formulation that focuses on the broadest range of benefits. The example Sites Reservoir project formulation is most similar to Initial Action Alternative Plan WSFQ from the PFR. Facilities and costs are generally the same. However, operations have been modified to account for new regulations in the Sacramento River and the Delta. This example project formulation allocates water in a way that meets the three primary objectives, ecosystem restoration, water supply, and water quality, somewhat equally. In addition, the example Sites Reservoir project formulation incorporates measures that would provide benefits to anadromous fish, including abandoned gravel mine restoration, spawning gravel replenishment, and instream aquatic habitat improvements.

The following sections summarize project features and costs for an example Sites Reservoir project formulation.

Example Sites Reservoir Project Formulation Project Features

Sites Reservoir would be an offstream storage reservoir. As noted previously, Sites Reservoir storage capacity is 1.8 MAF and is formed by two major and nine saddle dams. The example Sites Reservoir project formulation would include a proposed Delevan Pipeline (2,000-cubic feet per second [cfs] diversion and 1,500-cfs release capacities) to supplement the existing Tehama-Colusa Canal (2,100-cfs capacity near Sites) and Glenn-Colusa Irrigation District Canal (1,800-cfs capacity near Sites), to convey water to and from the reservoir (See Figure 3-3). All diversions to storage are conveyed through an enlarged Funks Reservoir that would serve as a forebay and afterbay for the Sites Pumping Plant and be used to regulate inflow or releases to and from Sites Reservoir. Although not included in this example project formulation, a large or separate downstream forebay/afterbay is under investigation to see if flexible generation benefits can be increased with this configuration.

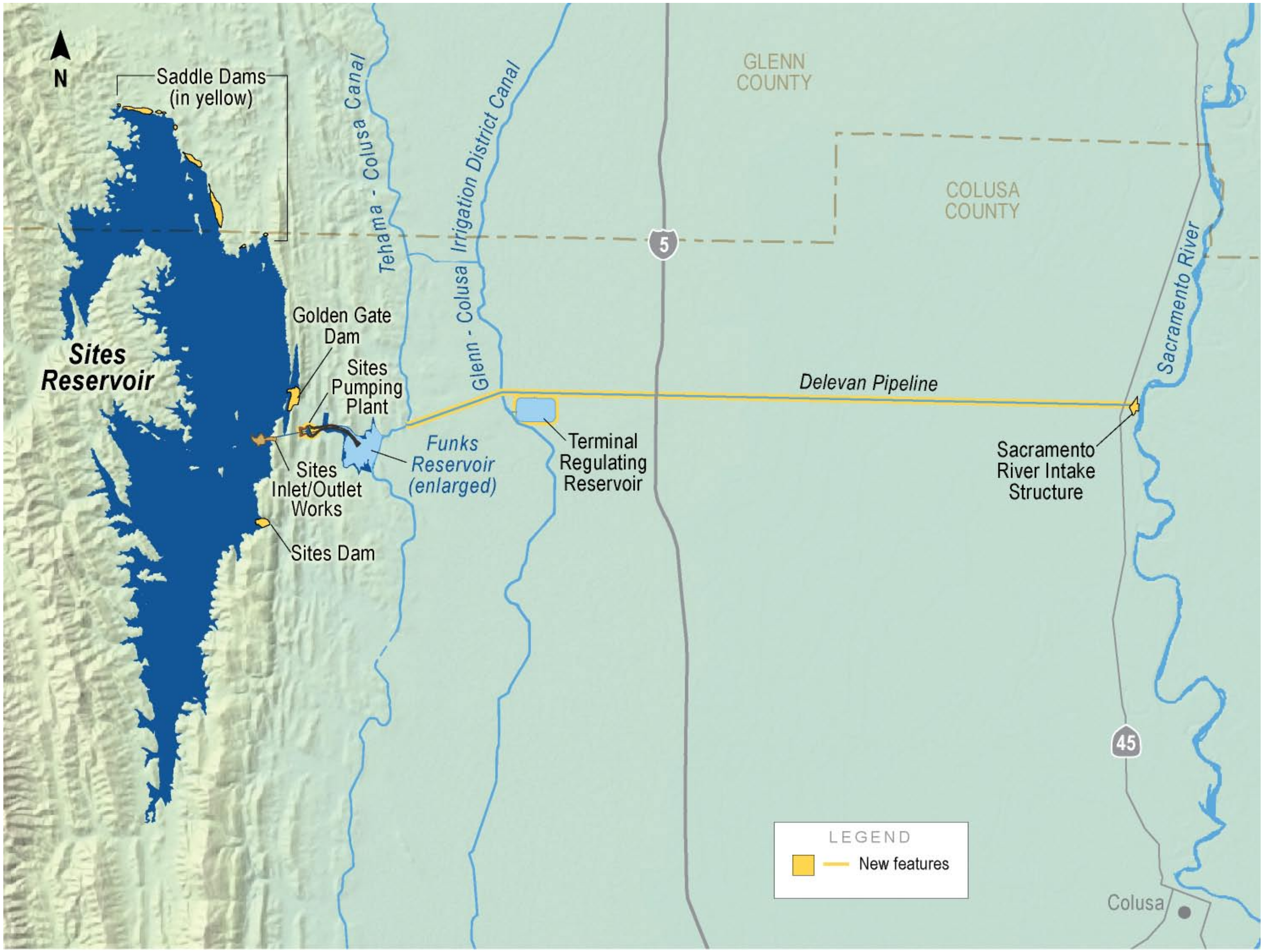

Figure 3-3. Sites Reservoir Inundation Area and Project Features

The example Sites Reservoir project formulation also would incorporate the following three measures that do not require supplemental water from Sites Reservoir to benefit anadromous fish:

- **Abandoned Gravel Mine Restoration:** The example Sites Reservoir project formulation would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. Restoration activities would be conducted in a manner to emulate natural conditions, encourage spawning and rearing, and prevent stranding.
- **Spawning Gravel Replenishment:** The example Sites Reservoir project formulation would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff.
- **Instream Aquatic Habitat Improvements:** The example Sites Reservoir project formulation would include restoring instream habitat along the lower arms of the Sacramento River. This activity would include improvements for shallow, warm-water habitat areas, spawning and rearing areas, and overall instream habitat conditions.

A summary of major project features of this example project formulation are listed below in Table 3-1.

Example Sites Reservoir Project Formulation Project Costs

The estimated capital cost for a new surface storage project at Sites Reservoir with a Delevan Pipeline as identified for the example Sites Reservoir project formulation is approximately $3.62 billion dollars (presented in 2007 dollars). Cost estimates include facilities costs, unlisted items, contingencies, indirect costs, mitigation, and interest during construction. The facilities and costs are the same as the PFR Initial Action Alternative WSFQ (Reclamation, 2008a). The cost estimate includes construction costs ($3.03 billion) and interest during construction ($0.59 billion). Project cost estimates are based on feasibility-level engineering designs for the various facilities, but costs are subject to change as the feasibility study progresses.

Example Sites Reservoir Project Formulation Operations

Operational priorities of the example Sites Reservoir project formulation are to improve both the water quality and the reliability of water supplies to SWP and CVP contractors; to provide long-term water supplies to support fish restoration actions; to improve the water supply reliability for wildlife refuges; and improve Delta water quality for water users and ecosystems and habitat. Operations of the reservoir would be fully integrated with the operation of the CVP and SWP systems to provide the array of benefits described later in this Chapter, as well as ensure that local conveyance and operations are respected.

The example Sites Reservoir project formulation would be operated to improve Delta water quality. Generally, water quality in the Delta diminishes over the summer and into the fall as inflow to the Delta decreases. Sites Reservoir could release up to 1,500 cfs through the Delevan Pipeline to the Sacramento River to improve Delta water quality. Improved water quality in the Delta is a benefit to both agricultural and urban users and to certain ecosystem functions. For example, conditions may be improved for Delta smelt by maintaining the location of the saltwater/freshwater interface further downstream in the Delta during specific periods.

Table 3-1. Summary of the Example Sites Reservoir Project Features

Project Feature	Details
Sites Reservoir	Gross Storage Capacity – 1.8 MAF Maximum Water Surface Elevation – 520 feet msl Minimum Operating Pool – 320 feet msl Inundation Area – 14,000 acres
Golden Gate Dam (Sites Reservoir)	Location – Funks Creek Earth Rockfill Embankment Dam Maximum Height – 310 feet
Sites Dam (Sites Reservoir)	Location – Stone Corral Creek Earth Rockfill Embankment Dam Maximum Height – 290 feet
9 Saddle Dams (Sites Reservoir)	Location - North end from Funks Creek to Hunters Creek Earth Rockfill Embankment Dams Dams 1, 2, 4, 9 – 40 to 50 feet high Dams 3, 5, 6, 7, 8 – 70 to 130 feet high
Emergency Spillway (Sites Reservoir)	Location – Saddle Dam 4
Sites Pumping/Generating Plant	Location – Downstream from Golden Gate Dam Pumping Capacity – 5,900 cfs Generating Capacity – 5,100 cfs
Funks Reservoir	Active Storage Volume – 3,800 AF
GCID Canal Fish Screens	Maximum Operating Flow – 150,000 cfs
GCID Canal	Existing Capacity to Terminal Regulating Reservoir (With Minor Reshaping) – 1,800 cfs
TC Canal	Existing Capacity at Funks Reservoir – 2,100 cfs
Terminal Regulating Reservoir and Pumping/Generating Plant	Storage Volume – 2,000 AF Pumping Capacity – 1,800 cfs Generating Capacity – 1,500 cfs
New Delevan Pipeline and Pumping/Generating Plant	Would provide a new point of diversion and release to the Sacramento River Pumping Capacity – 2,000 cfs Generating Capacity – 1,500 cfs
Ecosystem Restoration Account	Improve the reliability of cold water carry-over storage at Shasta Lake Increase supplemental flows for cold water release for salmon and steelhead on the Sacramento River Reduce diversions on the Sacramento River to provide water to TC and GCID Canals during July, August, and September Improve the reliability of cold water carry-over storage at Folsom Reservoir and stabilize flows in the American River Modify spring flows into a “snowmelt pattern” in years with peak storm events in late-winter on Sacramento River to support riparian establishment Stabilize fall flows to avoid abrupt reductions in the Sacramento River that may lead to stranding
Road Relocations and Access Roads	Road alignments Additional roads
Utility Relocations	Four- or Six-Breaker Ring Configurations
Hydroelectric Facilities	Hydropower, hydroelectric facilities would be added to many of the pumping plants as feasible
Recreation Facilities	Five Recreation Areas

AF	=	acre-feet	MAF	=	million acre-feet
cfs	=	cubic feet per second	msl	=	mean sea level
GCID	=	Glenn-Colusa Irrigation District	TC	=	Tehama-Colusa

In general, the reliability of water supplies is improved by the addition of storage to the CVP and SWP systems. With an example Sites Reservoir, SWP storage releases upstream of the Delta now could be made from two locations (Lake Oroville and Sites Reservoir) rather than one. Integrated operations with the CVP could be accomplished with even more flexibility because Sites Reservoir would be effectively downstream of Shasta Lake. Sites Reservoir could also deliver water directly to the service areas immediately adjacent to the reservoir. These service areas include a number of CVP contractors and water rights holders including the Glenn-Colusa Irrigation District and the Tehama-Colusa Canal Authority contractor service areas. Today, these contractors get most of their deliveries directly from the Sacramento River. Deliveries made from Sites Reservoir into these service areas would allow much of that water to remain in storage at Shasta Lake. This additional water left in storage at Shasta could then be used to accomplish many of the remaining benefits including water supply reliability and ecosystem restoration actions.

Ecosystem restoration actions are supported by dedication of reservoir resources (especially storage) to specific environmental benefits. To facilitate restoration actions, project planners conceived of an ecosystem restoration account (ERA) as part of Sites Reservoir operations. The basis of the account is derived from related planning efforts, including the CALFED ERP, which developed an integrated systems approach based on reversing the fundamental causes of decline in fish and wildlife populations by recognizing the natural forces that created historic habitats and using these forces to help regenerate habitats. The ERP was not designed as mitigation for CALFED projects; instead, it was intended to fulfill the objectives of improving ecological processes and increasing the amount and quality of habitat, equal with other CALFED program goals related to water supply reliability, water quality, and levee system integrity.

The ERP has been accommodated in NODOS planning by dedicating a NODOS storage allocation to ERP objectives (an ERP pool or account, i.e., the ERA), and then giving resource managers the ability to adjust priorities based on the monitoring of implemented actions, as well as potential new priorities. The NODOS planning team identified ERP objectives that could be supported by implementing a NODOS project and prioritized actions with input from the Sacramento River Flow Regime Technical Advisory Group. The list of potential ERP objectives includes both tributary actions and Delta actions.

The example Sites Reservoir project formulation presented in this report includes a set of ERP/ERA actions focused on the Sacramento River, and some improvements to the Feather River, American River, Trinity River, and the Delta. These restoration actions include:

- Improve the reliability of the cold water pool at Shasta Lake to support anadromous species
- Improve the reliability of the cold water pool at Trinity Lake to support anadromous species
- Improve the reliability of the cold water pool at Lake Oroville to support anadromous species
- Improve the reliability of the cold water pool at Folsom Lake to support anadromous species
- Improve instream temperature conditions in the Sacramento River below Shasta Lake for anadromous species with supplemental releases
- Stabilize Sacramento River fall flows below Shasta Lake to avoid fish stranding and reduce dewatering of redds and egg desiccation with supplemental releases
- Reduce diversion effects to fish at existing diversions on the Sacramento River by reducing the rate of larger diversions
- Improve conditions for cottonwood establishment and riparian success adjacent to the Sacramento River with supplemental releases

- Improve the location of the saltwater/freshwater interface (i.e., location of X2) in the Delta with supplemental releases to enhance conditions for Delta smelt

In the future, restoration managers may determine that a different set of actions have priority over the existing actions included here and that ERA assets be allocated to meeting higher priority objectives.

Example Sites Reservoir Project Formulation Benefits

For the purposes of this report, a simulation of system wide operations with historic streamflow conditions (i.e., CALSIM and related models) was used to determine the change in the average and driest periods benefits provided by an example Sites Reservoir project for primary purposes, including agricultural and M&I water supply reliability, refuge supply reliability, water quality, and ecosystem restoration.

This section describes benefits the example formulation of Sites Reservoir can provide when integrated with the SWP and CVP systems. The information presented in this section is for informational purposes only. The example Sites Reservoir project formulation was formulated to achieve a wide variety of objectives and may not represent the most technically and/or economically feasible alternative considered in past and/or future feasibility study reports and environmental documentation; therefore, it should not be considered as a preferred alternative.

A summary of the Sites Reservoir estimated benefits (yield) is provided in Table 3-2. However, as will be discussed in later sections, the volumes of water associated with ecosystem restoration actions with Sites Reservoir is much higher than the total yield shown in Table 3-2 because a specific amount of water can be used for multiple purposes. Benefits are allocated to ecosystem restoration, water supply reliability, and water quality categories. Long-term benefits for each of the beneficiary categories are equally distributed. The driest periods average benefit can be understood as drought benefit; this benefit is based upon the three historic statewide droughts from 1928-1934, 1976-1977, and 1986-1992. The importance of project performance during a statewide drought is discussed in Chapter 2.

Table 3-2. Summary of Potential Benefits (Yield) of the Example Sites Reservoir Project Formulation

Potential Beneficiary	NODOS Delivered Water Benefits (TAF/year)	
	Long-Term Average[1]	Driest Periods Average[2]
Ecosystem Restoration	180	66
Water Supply Reliability	183	209
Water Quality	197	112
Total	560	387

TAF = thousand acre feet

Notes:
[1] Long-term average is the average water supply for the period October 1922 to September 2003.
[2] Driest periods average is the average water supply for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

The following sections describe how the example Sites Reservoir project formulation would meet project objectives and achieve project benefits, including public benefits. This analysis presents Sites Reservoir project performance with current infrastructure and Delta operations, including actions identified in the 2008/2009 BOs. The presentation distinguishes between public benefits and non-public benefits based upon guidance from the 2009 Comprehensive Water Package. Potential benefits are illustrated on Figure 3-4.

Public Benefits

According to the 2009 Comprehensive Water Package, public benefits may include ecosystem restoration, water quality improvements, flood control benefits, emergency response, and recreation. Public benefits provided by the example project formulation include ecosystem improvements, flood control benefits, emergency response, and recreation. Water quality improvements for the environment would be achieved, but in this presentation all water quality benefits are discussed in the context of improved exported water quality and ecosystem improvements for simplicity. For this Progress Report, it was assumed that water supply reliability and water quality benefits for M&I and agricultural water users and hydropower/flexible generation are non-public benefits and would be paid for by users.

Ecosystem Improvements

It is challenging to report ecosystem restoration benefits in a manner that is easily understood. Therefore, the change in releases to Delta outflow that occur as a result of ecosystem restoration actions is reported in Table 3-2 to give a better sense of comparison with the other water release benefits, such as water supply reliability and water quality. This is intended to provide a conservative estimate of “yield” associated with the restoration actions supported by the Sites Reservoir ERA. Table 3-3 provides common physical and statistical measures of ecosystem restoration actions. An additional summary of restoration action volumes that occur as a result of the ERA actions is shown in Table 3-4 to provide a more complete picture of the quantities of water associated with these restoration actions. This water volume summary table depicts how efficiently new storage adjacent to the Sacramento River can move water around within the CVP and SWP systems. For example, many of these restoration actions are provided with the same water used two or three times and water may also be used for a restoration action upstream and then used for a water quality or water supply benefit downstream.

Temperature improvements in the rivers below large system reservoirs can be achieved two ways. First, retaining additional water in a reservoir at the end of the water year (September 30) improves the “cold water pool” of that reservoir. Water in near empty reservoirs warms rapidly. The performance measures shown in Table 3-3 reflect the reliability of the cold water pools at four CVP and SWP reservoirs. For example, the target storage for cold water pool maintenance at Shasta Lake is 2.2 MAF. With an example Sites Reservoir, the 2.2 MAF end-of-September target storage in Shasta Lake is achieved 84.1% of the time, 3.7% more often than without it. Second, increasing releases from a reservoir lowers river temperatures. The temperature improvements shown for the Sacramento River are a result of both actions: improved cold water pool and supplemental releases to achieve temperature targets. Cooler temperature is especially critical for anadromous species during dry or drought conditions. Therefore, the greater temperature improvements shown for driest periods (-1.4°F) compared to average (-0.4°F) is a desirable result.

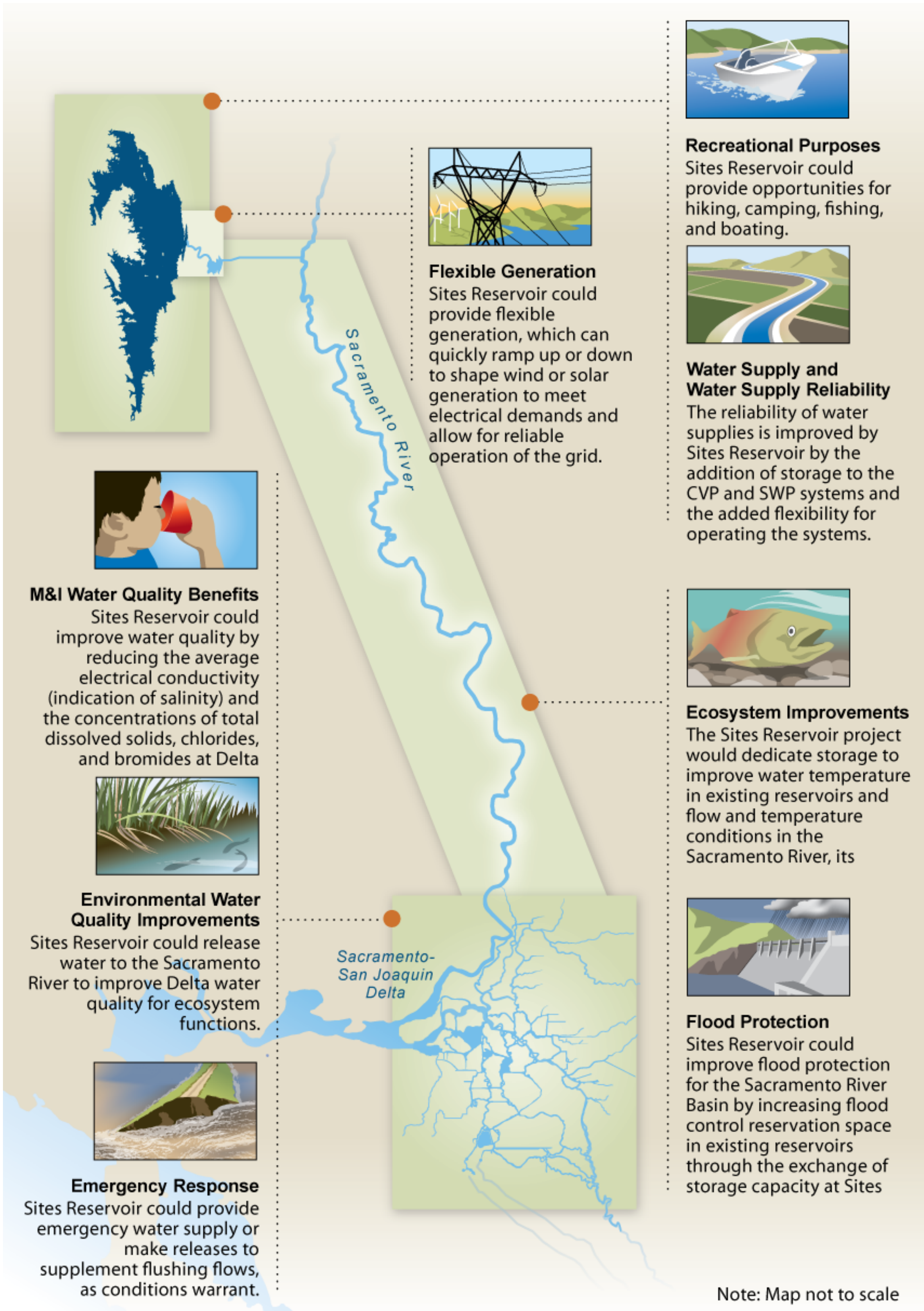

Figure 3-4. Summary of Potential Benefits of the Example Sites Reservoir Project

Each of the restoration actions listed in Table 3-4 has an associated volume of water, either a supplemental flow, a reduced diversion amount, or additional water in storage. The long-term average yield associated with restoration actions, 180 thousand acre-feet (TAF) (from Table 3-2), results in 666 TAF of restoration actions occurring at different locations throughout the Delta and related watersheds. While the yield associated with restoration actions diminishes significantly during driest periods, the volume of water resulting from the various restoration actions increases dramatically. During drought years, 66 TAF of restoration "yield" (Table 3-2) achieves 832 TAF of actions (Table 3-4) throughout the state's river systems and Delta. This improvement in restoration action efficiency is due in part to the conservative estimate of restoration action yield used for this report. Also, the system is much more efficient during drought periods. Water associated with a restoration action upstream is more likely to be used again before flowing out from the Delta. In that case, the water would not be accounted as ecosystem restoration "yield" in summary Table 3-2. However, all quantities of water associated with restoration actions are included in the water volume summary Table 3-4.

In addition to the ERA objectives, this example Sites Reservoir formulation also includes the following features to improve aquatic habitat conditions:

- Reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area to create valuable aquatic and floodplain habitat
- Replenishing gravel suitable for spawning in the Sacramento River
- Improving instream aquatic habitat to help provide favorable spawning conditions
- Improving adjacent shoreline habitat

Specific benefits associated with these actions that do not require additional water have not yet been quantified.

Table 3-3. Physical and Statistical Measures of Ecosystem Restoration Benefits of the Example Sites Reservoir Project Formulation

Potential Anadromous or Ecosystem Restoration Action/Target	Potential Physical and Statistical Measure Benefits	
	Long-Term Average[1]	Driest Periods Average[2]
Change in peak summer monthly upstream temperatures (°F) in the Sacramento River at Bend Bridge below Shasta Lake with supplemental releases	-0.4	-1.4
Shasta Lake performance measure [% of years with end of September storage greater than 2.2 MAF (% improvement)]	84.1 (+3.7)	NA
Lake Oroville performance measure [% of years with end of September storage greater than 1.1 MAF (% improvement)]	90.2 (+9.8)	NA
Folsom Lake performance measure [% of years with end of September storage greater than 300 TAF (% improvement)]	92.7 (+3.7)	NA
Trinity Lake performance measure [% of years with end of September storage greater than 600 TAF (% improvement)]	97.6 (+6.1)	NA

°F = degrees Fahrenheit; NA = not applicable

MAF = million acre feet; TAF = thousand acre feet

Notes: [1] Long-term average is the average for the period October 1922 to September 2003.

[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Table 3-4. Volumes of Water Associated with Ecosystem Restoration Actions of the Example Sites Reservoir Project Formulation

Potential Anadromous or Ecosystem Restoration Action/Target	Volume of Water Associated with Restoration Action (TAF/year)	
	Long-Term Average[1]	Driest Periods Average[2]
Stabilize Fall flows in the Sacramento River below Keswick (October-November) to prevent redd dewatering	218	88
Provide Spring flows for Cottonwood/Willow establishment in the Sacramento River (March-April)	51 (528 TAF/event) (8 events)	NA
Reduce TCCA/GCID diversions from the Sacramento River (April-October) to protect fish migration [total TAF/season associated with reduced diversion]	236	224
Shasta Lake cold water pool improvement	-20	271
Lake Oroville cold water pool improvement	165	134
Folsom Lake cold water pool improvement	20	42
Trinity Lake cold water pool improvement	-4	73
Additional releases to support March Delta outflow, May Freeport flow, and Yolo Bypass flow	NA	NA
Total volume of water associated with ERA ecosystem actions	666	832

ERA = ecosystem restoration account
GCID = Glenn-Colusa Irrigation District
MAF = million acre feet
NA = not applicable
TAF = thousand acre feet
TCCA = Tehama-Colusa Canal Authority

Notes:
1 Long-term average is the average for the period October 1922 to September 2003.
2 Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Flood Control Benefits/Flood Protection

Diversions from the Sacramento River would not be large enough to reduce peak flows significantly, based on previous analysis of alternatives presented in the NODOS PFR; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. Through coordinated operations with SWP and CVP and other flood control reservoirs and accurate forecasting, water could be held in Sites Reservoir in-lieu of water in other reservoirs to create flood control storage space in the other reservoirs. New analyses on flood damage reduction opportunities at the example Sites Reservoir project formulation were not conducted for this report. These analyses will be included in the feasibility study efforts.

Emergency Response/Storage

New analyses on emergency response opportunities at the example Sites Reservoir project formulation were not conducted for this report. These analyses will be included in the feasibility study efforts. However, the Sites Reservoir alternatives that include a Delevan Pipeline with a 1,500-cfs release capacity could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta. Although this would not be a large release, the proximity of Sites Reservoir to the Delta would make this an important feature because of the improved response time (flows would reach the Delta faster than they would from existing upstream reservoirs).

Recreational Purposes

New analyses on recreation opportunities at the example Sites Reservoir project formulation were not conducted for this report, but will be included in the Feasibility Report. However, Sites Reservoir could provide opportunities for hiking and camping and limited opportunities for fishing and boating. Sites Reservoir has the potential to affect flatwater, or reservoir-based, recreation at the reservoir itself and at Shasta Lake, Lake Oroville, and Folsom Lake. Operating strategies at Sites Reservoir would be employed to mitigate any impacts to recreation at Shasta Lake, Lake Oroville, and Folsom Lake (these impacts are not expected to be adverse and should be generally beneficial).

Water Supply Reliability Benefits

Following is a list of general water supply and water supply reliability needs that could be met directly by a potential NODOS project:

- Agricultural Water Supply Reliability
    - Local agricultural water districts
    - SWP contractors
    - CVP contractors
- M&I Water Supply Reliability
    - CVP contractors
    - SWP contractors
- Environmental Water Supply Reliability (this would be considered a public benefit)
    - Sacramento and San Joaquin Valleys Level 4 Refuge water supply

All water supply reliability benefits are shown in Table 3-2. Although included in Table 3-2 as water supply reliability, refuge water supply would likely be considered a public benefit. The drought yield for agricultural, M&I, and refuge water supply deliveries, is 209 TAF and the long-term average yield is 183 TAF. Weighting delivery priorities toward drought periods is accomplished by carrying over additional water in reservoirs from year to year. Specifically, water is retained in storage for use during dry or drought conditions. This operational approach could be modified to increase average water supply, which would result in a corresponding decrease in driest period water supply. Increased average year supply may be desirable for some water users.

M&I Water Quality Benefits

An example Sites Reservoir project could improve water quality by reducing the average electrical conductivity (indication of salinity) and the concentrations of total dissolved solids (TDS), chlorides, and bromides in deliveries from the Delta. For illustrative purposes, reductions in TDS at Banks Pumping Plant were modeled for the example Sites Reservoir project formulation (Table 3-5).

Water quality improvements may also benefit ecosystem and habitat conditions in the Delta and may qualify as a public benefit. For simplicity, all water quality benefits were considered non-public for this report.

Table 3-5. Potential Reductions in TDS at Banks Pumping Plant Due to the Example Sites Reservoir Project Formulation

Potential Water Quality Benefit	Potential Benefit	
	Long-Term Average[1]	Driest Periods Average[2]
Change in TDS exported at Banks Pumping Plant (mg/L)	-10.9	-3.1

mg/L = milligrams per liter TDS = total dissolved solids

Notes: [1] Long-term average is the average for the period October 1922 to September 2003.

[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Hydropower/Flexible Generation

Hydropower generation facilities in the example Sites Reservoir project formulation include the Sites Pumping/Generating plant between the main reservoir and Funks Reservoir, the Terminal Regulating Reservoir (TRR) Pumping/Generating plant between Funks Reservoir and the TRR, and the Delevan Pumping/Generating plant between Funks Reservoir and the Sacramento River. A potential Sites Reservoir also could have the capability to pump-back water at the Sites Pumping/Generating plant during standby or low operation times. Detailed analysis will be conducted as part of the feasibility study. Sites Reservoir could provide ancillary services to the statewide grid such as non-spin or regulation down which could aid in maintaining the electric system reliability and system frequency. Additionally, Sites Reservoir could provide shaping/firming power to allow the statewide grid to maintain electric system reliability and system frequency as more power is provided by non-dispatchable, intermittent wind and solar generation. These analyses will be completed in the draft Feasibility Report and EIS/EIR.

Based on information provided in the NODOS PFR, the initial Sites Reservoir alternatives are not intended to contribute a large supply of additional power to the statewide grid. A potential Sites Reservoir project would be, however, capable of adding power to the statewide grid during critical times of the year.

Example Sites Reservoir Project Formulation Benefits Under an Uncertain Future

As stated previously in this report, future conditions are uncertain at this time and considered projects must be able to fulfill project objectives and provide benefits under variable future conditions. This section describes new modeling conducted and presents new information on how an example Sites Reservoir project formulation could be coordinated with potential new Delta conveyance. The section also presents qualitative analysis on the potential of climate change to impact Sites Reservoir's ability to achieve project objectives. The information presented in this section is for informational purposes only.

Potential Effect of New Delta Conveyance on Project Benefits

Integration with new Delta conveyance would alter the operations of Sites Reservoir from those discussed previously in regards to water quality and ecosystem restoration actions. The relative value of improving Delta water quality diminishes with new conveyance in the Delta. The diversion of water from the lower Sacramento River associated with new Delta conveyance will significantly improve the quality of diverted water. Therefore, in this analysis a Delta water quality benefit is not shown for operations that include new Delta conveyance.

The performance of the NODOS ecosystem restoration actions varies with potential future conditions. Since the Delta water quality benefit is diminished with new Delta conveyance, the list of ERA actions would be larger under scenarios that include new Delta conveyance because more water would be available to dedicate to ERA actions. Therefore, ERA actions supported by the example Sites Reservoir formulation with new Delta conveyance include:

- All of the actions identified in the operation section with existing Delta conveyance
- Improve March Delta outflow with supplemental releases
- Increase May Freeport flows with supplemental releases
- Support flows through Yolo Bypass with supplemental releases

The results of analyses to evaluate the performance of the example Sites Reservoir project formulation with new Delta conveyance integrated with the CVP and SWP systems and the summary of benefits is displayed in Table 3-6. As noted previously, water quality benefits are assumed to be diminished with new Delta conveyance. Since the formulation with new Delta conveyance only supports two types of benefits, those average benefits (ecosystem restoration and water supply reliability) are greater.

Table 3-6. Summary of Potential Benefits (Yield) of the Example Sites Reservoir Project Formulation with New Delta Conveyance

Beneficiary	NODOS Delivered Water Benefits (yield) With New Delta Conveyance (TAF/year)	
	Long-Term Average[1]	Driest Periods Average[2]
Ecosystem Restoration	272	91
Water Supply Reliability	204	147
Water Quality	NM	NM
Total	476	238

NM = not modeled as a NODOS objective

TAF = thousand acre feet

Notes: [1] Long-term average is the average for the period October 1922 to September 2003.

[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

The following sections present how an example Sites Reservoir project formulation could accomplish project objectives and provide benefits under future operation scenarios that include potential new Delta conveyance, as being studied by the Bay-Delta Conservation Plan and Delta Habitat Conservation and Conveyance Program. The sections focus on analysis conducted for ecosystem improvements and water quality. Other benefit categories discussed previously that are not expected to change significantly with new Delta conveyance are not discussed again in this section; however, further analysis will be conducted as the feasibility study progresses.

Ecosystem Improvements

Table 3-7 shows the physical and statistical measures of ecosystem restoration benefits of Sites Reservoir implementation with new Delta conveyance. These benefits are generally similar with new Delta conveyance. The cold water pool improvements are generally less with the exception of Shasta Lake, which remains the same. Temperature improvements are slightly better with new Delta conveyance.

Table 3-7. Physical and Statistical Measures of Ecosystem Restoration Benefits of the Example Sites Reservoir Project Formulation with New Delta Conveyance

Potential Anadromous or Ecosystem Restoration Action/Target	Physical and Statistical Measure Benefits with New Delta Conveyance	
	Long-Term Average[1]	Driest Periods Average[2]
Change in peak summer monthly upstream temperatures (°F) in the Sacramento River at Bend Bridge below Shasta Lake with supplemental releases	-0.8	-1.5
Shasta Lake performance measure [% of years with end of September storage greater than 2.2 MAF(% improvement)]	86.6 (+3.7)	NA
Lake Oroville performance measure [% of years with end of September storage greater than 1.1 MAF(% improvement)]	92.7 (+7.3)	NA
Folsom Lake performance measure [% of years with end of September storage greater than 300 TAF(% improvement)]	90.2 (+0)	NA
Trinity Lake performance measure [% of years with end of September storage greater than 600 TAF(% improvement)]	97.6 (+2.4)	NA

°F = degrees Fahrenheit MAF = million acre feet
NA = not applicable TAF = thousand acre feet
Notes: [1] Long-term average is the average for the period October 1922 to September 2003.
[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

The volumes of water associated with the ecosystem restoration actions supported by Sites Reservoir are shown in Table 3-8. The total volume of water with Sites Reservoir and new Delta conveyance are greater for long-term average, but lesser during drought. The volumes of additional water associated with the cold water pools at the reservoirs seem to be most affected by adding new Delta conveyance.

Table 3-8. Volumes of Water Associated with Ecosystem Restoration Actions of the Example Sites Reservoir Project Formulation with New Delta Conveyance

Potential Anadromous or Ecosystem Restoration Action/Target	Volume of Water Associated with Restoration Action (TAF/year)	
	Long-Term Average[1]	Driest Periods Average[2]
Stabilize Fall flows in the Sacramento River below Keswick (October-November) to prevent red dewatering	227	127
Provide Spring flows for Cottonwood/Willow establishment in the Sacramento River (March-April)	51 (533 TAF/event) (8 events)	NA
Reduce TCCA/GCID diversions from the Sacramento River (April-October) to protect fish migration [total TAF/season]	301	276
Shasta Lake cold water pool improvement	29	136
Lake Oroville cold water pool improvement	141	130
Folsom Lake cold water pool improvement	16	4
Trinity Lake cold water pool improvement	-4	17
Additional releases to support March Delta outflow, May Freeport flow, and Yolo Bypass flow	93	5
Total volume of water associated with ERA ecosystem actions	854	695

ERA = ecosystem restoration account GCID = Glenn-Colusa Irrigation District
NA = not applicable TAF = thousand acre feet
TCCA = Tehama-Colusa Canal Authority
Notes: [1] Long-term average is the average for the period October 1922 to September 2003.
[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Water Quality Improvements

As shown in Table 3-9, there is some improvement in TDS with the example Sites Reservoir project and new Delta conveyance, but the need for improvement is likely less significant due to water quality improvements provided by new Delta conveyance alone.

Table 3-9. Potential Reductions in TDS at Banks Pumping Plant Due to the Example Sites Reservoir Project Formulation with New Delta Conveyance

Potential Water Quality Benefit	Potential Benefit	
	Long-Term Average[1]	Driest Periods Average[2]
Change in TDS export at Banks Pumping Plant (mg/L)	-4.8	-1.1

mg/L = milligrams per liter
TDS = total dissolved solids
Notes: [1] Long-term average is the average for the period October 1922 to September 2003.
[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Potential Effect of Climate Change on Project Benefits

As noted in Chapter 2, Water Management Issues and Challenges, climate change effects upon California's water resources are already being observed and are anticipated to increase over time. The following qualitative discussion of climate change effects to the operation of Sites Reservoir are intended to provide the types of effects that are anticipated to occur. As part of the feasibility study, the NODOS Investigation plans to provide a more detailed analysis of climate change effects. An operations simulation of the example Sites Reservoir project formulation with climate change was not included in this study effort. However, previous simulations of a similar formulation and future conditions with climate change inform this report.

A number of climate change effects will modify either future conditions or the functional capability of Sites Reservoir:

- Sea level rise will require more water from upstream reservoirs to maintain water quality in the Delta
- Carryover storage at system reservoirs will be diminished significantly and is related in part to the additional water required to repel salinity in the Delta, causing both system vulnerabilities and local adverse effects
- Higher temperatures will decrease Sierra snowpack storage, changing runoff timing, intensity, and duration
- Unmet demands will increase

The specific effects to the example Sites Reservoir operations and benefits are not quantified here. Generally, the greatest effect will likely be an increase in unmet demand associated with the factors described above.

Sites Reservoir Potential Environmental Effects

Primary potential effects for aquatic biological, terrestrial biological, and cultural resources affected by an example Sites Reservoir are described in the PFR. Examples of potential adverse effects described in the PFR include inundation of terrestrial habitats and associated species and inundation of cultural resources sites. Potential beneficial effects, such as improved habitat and flow conditions in the Sacramento River and improved recreation opportunities, are also described in the PFR.

Additional environmental analyses will be completed during the feasibility study which will inform the nature of potential mitigation and/or enhancement measures included in Sites Reservoir alternative plans, and included in the Draft and Final Feasibility Report and accompanying EIS/EIR. Construction of a new reservoir at Sites would be subject to the requirements of numerous federal, state, and local laws, policies, and regulations. Reclamation is the lead agency for National Environmental Policy Act (NEPA) compliance, and DWR is the lead agency for California Environmental Quality Act (CEQA) compliance. Moreover, DWR and Reclamation would need to obtain various permits and meet regulatory requirements before beginning any project construction, and comply with a number of environmental regulatory requirements as part of the NEPA and CEQA compliance process.

A draft EIS/EIR disclosing environmental effects resulting from the NODOS Investigation is scheduled for release in 2011. Environmental studies and evaluations are currently being conducted to determine the type and extent of potential environmental impacts. It is anticipated that some of the adverse effects would be temporary, construction related effects and other adverse effects would be permanent, such as effects on botanical and wildlife resources within the newly inundated areas. As part of the project planning and environmental assessment process, DWR and Reclamation will incorporate environmental commitments and best management practices to avoid or minimize potential effects. DWR and Reclamation have also committed to coordinate with applicable resource agencies and tribal groups during planning, engineering, design, construction, operation, and maintenance phases of the project. The Feasibility Report and EIS/EIR will also include a greenhouse gas emission analysis and a sensitivity analysis evaluating the potential effects of climate change on the project.

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